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UTILITY PATENT APPLICATION TRANSMITTAL
(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No. <u>003551.P007</u>   Total Pages <u>3</u>

First Named Inventor or Application Identifier <u>Thomas W. Jewitt</u>

Express Mail Label No. <u>EL 234 217 497 US</u>

ADDRESS TO: **Assistant Commissioner for Patents**
                  Box Patent Application
                  Washington, D. C. 20231

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

1. <u>X</u> Fee Transmittal Form
         (Submit an original, and a duplicate for fee processing)

2. <u>X</u> Specification   (Total Pages <u>25</u>)
         (preferred arrangement set forth below)
         - Descriptive Title of the Invention
         - Cross References to Related Applications
         - Statement Regarding Fed sponsored R & D
         - Reference to Microfiche Appendix
         - Background of the Invention
         - Brief Summary of the Invention
         - Brief Description of the Drawings (if filed)
         - Detailed Description
         - Claims
         - Abstract of the Disclosure

3. <u>X</u> Drawings(s) (35 USC 113)   (Total Sheets <u>13</u>)

4. <u>X</u> Oath or Declaration   (Total Pages <u>4</u>)

     a. <u>X</u> Newly Executed (Original or Copy)

     b. ___ Copy from a Prior Application (37 CFR 1.63(d))
              (for Continuation/Divisional with Box 17 completed) **(Note Box 5 below)**

     i. ___ <u>DELETIONS OF INVENTOR(S)</u> Signed statement attached deleting
              inventor(s) named in the prior application, see 37 CFR 1.63(d)(2)
              and 1.33(b).

5. _____ Incorporation By Reference (useable if Box 4b is checked)
          The entire disclosure of the prior application, from which a copy of the oath or
          declaration is supplied under Box 4b, is considered as being part of the
          disclosure of the accompanying application and is hereby incorporated by
          reference therein.

6. _____ Microfiche Computer Program (Appendix)

7. _____ Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
a. _____ Computer Readable Copy
b. _____ Paper Copy (identical to computer copy)
c. _____ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. __X__ Assignment Papers (cover sheet & documents(s))

9. _____ a. 37 CFR 3.73(b) Statement (where there is an assignee)

   __X__ b. Power of Attorney (Executed)

10. _____ English Translation Document (if applicable)

11. _____ a. Information Disclosure Statement (IDS)/PTO-1449

    _____ b. Copies of IDS Citations

12. _____ Preliminary Amendment

13. __X__ Return Receipt Postcard (MPEP 503) (Should be specifically itemized)

14. _____ a. Small Entity Statement(s)

    _____ b. Statement filed in prior application, Status still proper and desired

15. _____ Certified Copy of Priority Document(s) (if foreign priority is claimed)

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17. **If a CONTINUING APPLICATION,** check appropriate box and supply the requisite information:

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    __X__ Correspondence Address Below

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Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: 28 Sept., 2000 By _Dennis A. Nicholls_
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_9-28-2000_
(Date signed)

Serial/Patent No.: __* *__   Filing/Issue Date: **Herewith**
Client: **Oak Technology, Inc.**
Title: **System and Method For A Robust De-Screening Filter**

BSTZ File No.: __03551.P007-__   Atty/Secty Initials: **JAS/DAN/td**
Date Mailed: __9-28-2000__   Docket Due Date: __* *__

The following has been received in the U.S. Patent & Trademark Office on the date stamped hereon:

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☒ Application - Utility (_25_ pgs., with cover and abstract)	☐ Information Disclosure Statement & PTO-1449 (___ pgs.)	☐ Check No._____
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☒ Assignment and Cover Sheet	☐ Reply Brief (_____ pgs.)	
☒ Certificate of Mailing **(Express Mail)**	☐ Response to Notice of Missing Parts	
☒ Declaration & POA (_4_ pgs.) **(Executed)**	☐ Small Entity Declaration for Indep. Inventor/Small Business	
☐ Disclosure Docs & Orig. & Copy of Inventors Signed Letter (_____ pgs)	☒ Transmittal Letter, in duplicate **(3 pages)**	
☒ Drawings: _13_ # of sheets includes _14_ figures	☒ Fee Transmittal, in duplicate	

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3

FEE TRANSMITTAL FOR FY 2000

TOTAL AMOUNT OF PAYMENT ($) $ 1,000.00

Complete if Known:
Application No.   Not Yet Assigned
Filing Date   September 28, 2000 (concurrently herewith)
First Named Inventor Thomas W. Jewitt
Group Art Unit   Not Yet Assigned
Examiner Name   Not Yet Assigned
Attorney Docket No.   003551.P007

METHOD OF PAYMENT (check one)

1.   [X]   **The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:**

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FEE CALCULATION

1.   BASIC FILING FEE

Large Entity		Small Entity			
Fee Code	Fee ($)	Fee Code	Fee ($)	Fee Description	Fee Paid
101	690	201	345	Utility application filing fee	690.00
106	310	206	155	Design application filing fee	_____
107	480	207	240	Plant filing fee	_____
108	690	208	345	Reissue filing fee	_____
114	150	214	75	Provisional application filing fee	_____

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2.   EXTRA CLAIM FEES

		Extra Claims	Fee from below		Fee Paid
Total Claims 22	– 20** =	2	X	18.00	= 36.00
Independent Claims 6	– 3** =	3	X	78.00	= 234.00
Multiple Dependent				_____	= _____

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103	18	203	9	Claims in excess of 20
102	78	202	39	Independent claims in excess of 3
104	260	204	130	Multiple dependent claim, if not paid
109	78	209	39	**Reissue independent claims over original patent
110	18	210	9	**Reissue claims in excess of 20 and over original patent

                                              SUBTOTAL (2) $ 270.00

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FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	_____
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	_____
139	130	139	130	Non-English specification	_____
147	2,520	147	2,520	For filing a request for reexamination	_____
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	_____
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	_____
115	110	215	55	Extension for response within first month	_____
116	380	216	190	Extension for response within second month	_____
117	870	217	435	Extension for response within third month	_____
118	1,360	218	680	Extension for response within fourth month	_____
128	1,850	228	925	Extension for response within fifth month	_____
119	300	219	150	Notice of Appeal	_____
120	300	220	150	Filing a brief in support of an appeal	_____
121	260	221	130	Request for oral hearing	_____
138	1,510	138	1,510	Petition to institute a public use proceeding	_____
140	110	240	55	Petition to revive unavoidably abandoned application	_____
141	1,210	241	605	Petition to revive unintentionally abandoned application	_____
142	1,210	242	605	Utility issue fee (or reissue)	_____
143	430	243	215	Design issue fee	_____
144	580	244	290	Plant issue fee	_____
122	130	122	130	Petitions to the Commissioner	_____
123	50	123	50	Petitions related to provisional applications	_____
126	240	126	240	Submission of Information Disclosure Stmt	_____
581	40	581	40	Recording each patent assignment per property (times number of properties)	40.00
146	690	246	345	For filing a submission after final rejection (see 37 CFR 1.129(a))	_____
149	690	249	345	For each additional invention to be examined (see 37 CFR 1.129(a))	_____

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SUBMITTED BY:

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Signature _____ Date 28 Sept. , 2000

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UNITED STATES PATENT APPLICATION

FOR

SYSTEM AND METHOD FOR A
ROBUST DE-SCREENING FILTER

INVENTOR:

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SYSTEM AND METHOD FOR A

ROBUST DE-SCREENING FILTER

FIELD OF THE INVENTION

5   The present invention relates to halftone printing technology, and

more specifically, to undoing the effects of halftone printing technology.

BACKGROUND

Photographic images may be printed onto photographic film with

great ease. All that is required is an optical path and unexposed film.

10   In contrast with this, printing onto with a finite number of inks or wax

transfers requires a technique that allows for gradation of shades with a

single ink color. Each ink gives only the possibility of being applied (full

intensity) or not being applied (zero intensity).

Perhaps the most common technique for allowing gradation of

15   shades is the halftone system. In the halftone system, to emulate a

gray midway between black and white, a small number of dots is

printed on a white background. The ratio of the area covered by the

dots to the area left uncovered determines how gray is the area.

Referring now to Figure 1, a diagram of a photographic film based

20   halftone system is shown. Other halftone systems may utilize digital

techniques, but the outcome is approximately the same. In the Figure

1 example, an original print 100 has medium gray area 102, light gray

area 106, dark gray area 104, white area 110, and black area 108. The original print 100 is projected via lens 120 onto a contact screen 124 and finally onto a film negative 142. The contact screen is a precision piece of film with a pattern of transparent areas 126 alternating in a

5 grid with opaque areas 128. The contact screen is so constructed that the opacity gradually changes from total in opaque areas 128 to not opaque in transparent areas 126.

In a controlled exposure, light coming from a white area 110 is intense enough that the entire area 138 is exposed (blackened on a

10 negative). But with no light coming from a black area 108 the area 140 is not exposed at all (stays white on a negative). In a medium gray area 102, the reflected light is strong enough to expose the film negative 136 in much of the area adjacent to the corresponding transparent areas of contact screen 124 but not strong enough to expose the film negative

15 142 in the area adjacent to the corresponding opaque areas of contact screen 124. This yields an area of medium-sized dots 132. For the light gray area 106 the exposure yields an area of larger dots 134, and for the dark gray area 104 the exposure yields an area of smaller dots 136.

20 The film negative 142 may be used as a printing master, with the black areas etched so that only the white areas can carry the ink. When viewed from a suitable distance, an image printed from film

negative 142 has a corresponding replica of the original print 100.
When viewed from a suitable distance, the replica will look like the
original print 100 to a viewer.

The Figure 1 discussion was concerned with traditional optics
5   and photographic film. A similar process may be performed with digital
technology, wherein the contact screen is replaced by a digital sampling
technique. The resulting dotted image may be used to generate a
printing master in an analogous manner.

Referring now to Figure 2, a diagram showing screen angles in a
10   color halftone system is shown. The Figure 1 discussion was for a
black and white image. When printing color images, additional
complications arise. Printing in color requires the use of the three
subtractive primary colors, cyan (C), magenta (M), and yellow (Y). To
achieve the best results, a fourth ink, black (K) is added to the CMY
15   palate, creating a CMYK palate.

Four separate exposures, under different colored lights, create
four separate film negatives for use as printing masters. However,
printing inks are somewhat opaque, and if the same orientation of the
contact screen is used for each color, what you will see is a print with
20   the dots stacked one on top of the other. The dot printed last would be
most visible. Therefore, the contact screen is rotated by an angle prior
to the exposures that create the C film negative, the M film negative, the

Y film negative, and the K film negative. The best results occur when there is a 30 degree angle between the exposures. However, with four colors this is not possible. A best compromise has been found where the C, M, and K exposures are made with the contact screen rotated by

5 30 degrees between exposures, and by making the Y exposure with the contact screen midway between the C and M angles. One such possibility is shown in Figure 2. When the corresponding film negatives are converted into printing masters, a four-color CMYK halftone print may be printed.

10 Problems arise when the resulting CMYK halftone print is itself a candidate for subsequent scanning. When the resulting scanned image is used for either printing or direct electronic use, such as posting the image on a web page, the halftone nature of the source image will cause poor quality in either of the resulting images. Such subsequent

15 scanning and printing or other use may take place in a computer system with a scanner and laser printer, or may take place in a digital photocopier. In each case complications arise because the CMYK halftone print has already gone through the halftone process. After scanning, subsequent attempts with screening processes may produce

20 a poor subsequent halftone print, with blurry areas and the possibility of Moire effects. These effects are well-known to anyone who has attempted to make a photocopy of a halftone print. Similarly, after

scanning, subsequent use as an electronic image on a web page will exhibit poor image quality.

Prior art techniques for avoiding these problems have been limited by a requirement of either knowing detailed information about how the source halftone print was produced, or by using an inefficient trial-and-error method. The detailed information required may include the screen frequency (inversely proportional to the distance between transparent areas in a contact screen), screen angles (such as shown in Figure 2), the shape of the halftone dots, and many other parameters. It is highly unlikely that a copy machine operator would know the values of these parameters or even what they are. There are currently about 20 halftone screening procedures in common use, and each requires a specific procedure to undo the effects of the halftone screening. The large number of these procedures may make their use on a trial-and-error basis very time consuming.

SUMMARY OF THE INVENTION

A method and apparatus for de-screening a halftone image, therefore allowing the recovery of an approximation of an original image, is disclosed. A method according to one embodiment first performs a screen conversion filter upon a scanned representation of the halftone image to produce an intermediate image. This method then performs a line smoothing filter upon the intermediate image to produce an output image that approximates an original image.

In an alternate embodiment, the method performs a single convolution filter upon a scanned representation of the halftone image to produce an output image. In this embodiment, the single convolution filter is equal to the resulting convolution of first performing a screen conversion filter and then performing a line smoothing filter.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

5   Figure 1 is a diagram of a photographic film based halftone system.

Figure 2 is a diagram showing screen angles in a color halftone system.

Figure 3 is an illustration of one embodiment of a computer

10   system.

Figure 4 is a block diagram of one embodiment of a computer system in accordance with the present invention.

Figure 5 is a software module diagram of one embodiment of the computer system in accordance with the present invention.

15   Figure 6 is a chart illustrating the calculation of a filtered value for a pixel, according to one embodiment of the present invention.

Figure 7A is a diagram of a first convolution filter according to one embodiment of the present invention.

Figure 7B is a diagram of a second convolution filter according to

20   one embodiment of the present invention.

Figure 8 is a diagram of a scanned image of one embodiment of the present invention.

Figure 9 is a diagram of an output image from a first filter according to one embodiment of the present invention.

Figure 10 is a diagram of an output image from a second filter according to one embodiment of the present invention.

5 Figure 11 is a graph of a first convolution filter frequency response according to one embodiment of the present invention.

Figure 12 is a graph of a second convolution filter frequency response according to one embodiment of the present invention.

Figure 13 is a graph of a combined filter frequency response 10 according to another embodiment of the present invention.

DETAILED DESCRIPTION

A system and method for recreating a source image from an existing ("parent") halftone print is described. This method will be referred to as a "de-screening" process, because it aims to undo the

5   effects created in a prior operation by a halftone contact screen or its digital equivalent. A system using this method will be referred to as a "de-screening filter". In the de-screening process, detailed knowledge of the prior halftone process is not necessary to create a subsequent ("daughter") halftone print in a laser printer or photocopier.

10   The de-screening process begins with the scanning of the parent halftone print. The digital representation created by this scanning process is then processed by a screen conversion filter. The output of the screen conversion filter is then processed by a line smoothing filter. The output of the line smoothing filter is a digital representation which

15   may serve as the digital representation of the original parent image. This digital representation of the original parent image may then be processed in a subsequent halftone process to produce a clear daughter halftone print.

Referring now to Figure 3, an illustration of one embodiment of a

20   computer system 300 of the present invention is shown. The computer system 300 includes a computer 310, a scanner 314, a laser printer 318, a monitor 322, and a keyboard 326. The component of the

computer system 300 are connected via scanner interface cable 312,

printer interface cable 316, monitor interface cable 320, and keyboard

interface cable 324. A parent halftone print 350 may be inserted into

scanner 314 for the purpose of scanning. The laser printer 318 may

5   then produce a subsequent daughter halftone print 360. In other

embodiments, the components of computer system 300 or their

equivalents may be combined into a digital photocopier.

Scanner 314 may be used to produce a digital representation of

the parent halftone print 350 under control of computer 310. An

10   operator using keyboard 326 and monitor 322 may select portions of

the scanned digital representation for subsequent processing and

printing on laser printer 318. Computer 310 may coordinate these

efforts, and, additionally, may perform the screen conversion filter and

line smoothing filter operations of the present invention. In alternate

15   embodiments, these filtering operations may be performed by embedded

processors within laser printer 318 or scanner 314.

Referring now to Figure 4, a block diagram of one embodiment of

a computer system is shown, in accordance with the present invention.

Computer 310 may include a central processing unit (CPU) 410, a

20   memory 414, a digital signal processor (DSP) 418, a disk 420, and a

removable media 424. The CPU 410 may be a conventional complex

instruction set computer (CISC) or a reduced instruction set computer

(RISC). The memory 414 may be homogeneous or a mixture of kinds of memory, and may include dynamic random-access memory (DRAM), static random-access memory (SRAM), flash-programmable read-only memory (Flash), or other kinds of read-only memory (ROM). An

5   optional DSP 418 may be included to facilitate complex numerical calculations. Disk 420 may be magnetic, optical, or magneto-optical in nature. In other embodiments, a large area of non-volatile memory may be used instead of a disk 420 for program storage. Removable media 424 may be a removable magnetic disk, a floppy disk, an optical disk, a

10   magneto-optical disk, or a memory card.

The components of the computer 310 may be connected by a central data bus 404. Additionally, local busses may be used, such as local bus 412 between CPU 410 and memory 414, or local bus 416 between DSP 418 and memory 414. Various input/output (I/O)

15   controllers such as universal serial bus (USB) couplers 428, 438, local area network (LAN) coupler 430, and graphics engine 434 may also be connected via data bus 404. In alternate embodiments other interfaces may be used to connect with the scanner 314, the laser printer 318, the monitor 322, and the keyboard 326.

20   Referring now to Figure 5, a software module diagram of one embodiment of the computer system is disclosed, in accordance with the present invention. In the Figure 5 embodiment, the computer 310

controls the scanning performed by the scanner 314. Computer 310 also performs the screen conversion filter process and the line smoothing filter process. Software modules scanning driver 510, first convolution filter 520, and second convolution filter 530 may be

5   resident within memory 414. In other embodiments, these three processes may be performed by a smart scanner, a smart laser printer, or by a digital photocopier.

First convolution filter 520 may serve as the screen conversion filter. In alternate embodiments, first convolution filter 520 may serve

10   as the line smoothing filter. Second convolution filter 530 may serve as the line smoothing filter. In alternate embodiments, second convolution filter 530 may serve as the screen conversion filter. Details of these filters will be provided in connection with Figures 6, 7A, and 7B below.

Referring now to Figure 6, a chart illustrating the calculation of a

15   filtered value for a pixel is shown, according to one embodiment of the present invention. Matrix 600 represents the digital representation of the scanned halftone print. Each location within the matrix 600 is a picture element (pixel) and contains a numeric value (for monochrome scanners) or a set of three numeric values (for color scanners)

20   representing the brightness of the pixel. In the following discussion it will be assumed that the single numeric value (monochrome) example will be discussed, but it should be noted that the three numeric value

(color) embodiment merely replicates the monochrome filtering process three times.

An exemplary pixel is pixel 620, in the i'th column and j'th row of matrix 600. Pixel 620 will be used to show the operation of one of the convolution filters. Let the original numeric value in pixel 620 be a_{ij}. The filtered value for the pixel 620 may be called b_{ij}. The value of b_{ij} is derived by taking a linear combination of a_{ij} and the values of the 8 neighboring pixels 612, 614, 616, 618, 622, 624, and 628 in a 3 by 3 submatrix 610 of matrix 600. In other embodiments, submatrix 610 may be a 4 by 4 submatrix, a 5 by 5 submatrix, or any other size submatrix. The matrix of all the b_{ij} (not shown) is the output matrix of the convolution filter.

Referring now to Figure 7A, a diagram of a first convolution filter is shown, according to one embodiment of the present invention. In this embodiment, the filter of Figure 7A forms a screen conversion filter. In alternate embodiments, the filter of Figure 7A may be used as a line smoothing filter. Coefficient matrix 700 contains the constant coefficients which will be used in the first convolution filter. The elements of coefficient matrix 700 are zero everywhere except on the diagonal going from upper left to lower right. Here c(+1, -1) = c(-1, +1) = 1, and c(0, 0) = 2. The coefficients are multiplied by the corresponding pixel's numeric values in each submatrix. All these products are then

summed to give the output numeric value b_{ij}. The double summation in the equation of Figure 7A collapses to a simple sum, since $2a_{ij} = a_{ij} + a_{ij}$. Therefore the first convolution filter of Figure 7A may be calculated in an efficient manner with three additions and no multiplications.

5   Referring now to Figure 7B, a diagram of a second convolution filter is shown, according to one embodiment of the present invention. In this embodiment, the filter of Figure 7B forms a line smoothing filter. In alternate embodiments, the filters of Figure 7A and 7B may be reversed, with the filter of Figure7B being used as the screen conversion

10   filter. Coefficient matrix 750 contains the constant coefficients which will be used in the second convolution filter. The elements of coefficient matrix 750 are zero everywhere except on the diagonal going from lower left to upper right. Here $c_{(+1, +1)} = c_{(-1, -1)} = 1$, and $c_{(0, 0)} = 2$. As in the case of the first convolution filter of Figure 7A, the coefficients are

15   multiplied by the corresponding pixel's numeric values in each submatrix. All these products are then summed to give the output numeric value b_{ij}. The double summation in the equation of Figure 7B again collapses to a simple sum, since $2a_{ij} = a_{ij} + a_{ij}$. Therefore the second convolution filter of Figure 7B may also be calculated in an

20   efficient manner with three additions and no multiplications.

Referring now to Figure 8, a diagram of a scanned image of one embodiment of the present invention is shown. In the Figure 8

example, a CMYK halftone print has been created using a method similar to that outlined in the discussions of Figure 1 and Figure 2 above. The round "rosette" marks are common to halftone prints when examined at great magnification. The halftone print has been digitally

5 scanned and the resulting data placed into a pixel matrix similar to that shown in Figure 6 above. What is shown in Figure 8 is the resulting image if this pixel matrix were printed directly onto a high-resolution laser printer.

Referring now to Figure 9, a diagram of an output image from a

10 first convolution filter is shown, according to one embodiment of the present invention. In the Figure 9 example, the data representing the image of Figure 8 was processed in a first convolution filter, such as that shown in Figure 7A, used as a screen conversion filter. The Figure 7A filter, when used in this manner, produces lines along a 45 degree

15 angle. It should be noted that the Figure 9 image is for illustration only as this is an intermediary result. In other embodiments, using the Figure 7B filter as a screen conversion filter may produce lines along a 135 degree angle.

It is noteworthy that the filtering as shown in the Figure 9

20 example does not produce Moire patterns. The resulting lines along the 45 degree angle (or 135 degree angle) are parallel and thus have an angle of 0 degrees between them. It is well-known in the art that

patterns of intersecting lines intersecting at an angle of θ may produce

Moire patterns with a interference period T given by $T = K/\sin(\theta/2)$,

where K is a constant of proportion. Since in the present example θ =

0, and since $\sin(0) = 0$, the interference period T is infinite. Hence the

5   use of the Figure 7A filter to produce the exemplary image of Figure 9

has the benefit of preventing Moire effects.

Referring now to Figure 10, a diagram of an output image from a

second filter is shown, according to one embodiment of the present

invention. This image presumes that the Figure 9 filtering was first

10   performed with the filter of Figure 7A. The Figure 10 filtering, the line

smoothing filtering step, would then be accomplished with the filter of

Figure 7B. In an alternate embodiment, the Figure 7B filter would be

used as the screen conversion filter followed by the Figure 7A filter as

the line smoothing filter.

15   The image shown in Figure 10 is an exemplary final result of the

filtering process of the present invention. From the point of view of a

subsequent laser printer or photocopier, this image loses most of the

artifacts originally introduced by the halftone process. In effect, the

artifacts introduce by the halftone screens have been removed, which

20   leads to the filtering process of the present invention being referred to

as a "de-screening filter". In no part of the de-screening process were

the original parameters of the halftone process required. The de-

screening process of the present invention works independently of any previous halftone screening processes.

Referring now to Figure 11, a graph of a first filter frequency response is shown, according to one embodiment of the present invention. This graph illustrates the frequency response of the filter of Figure 7A. If the input values a_{ij} at each location of a matrix are considered as a function of a two dimensional discrete-valued variable, then the frequency response of the filter of Figure 7A may be derived using techniques well-known in the art. The frequency response curve shown in Figure 11 has the result of passing low-frequencies, passing high-frequencies along the diagonal line from lower left to upper right, and attenuating high-frequencies away from this diagonal line (e.g. along the horizontal and vertical axis). Alternate filters to that of Figure 7A may be used when the alternate filter has a frequency response curve similar to that shown in Figure 11.

Referring now to Figure 12, a graph of a second filter frequency response is shown, according to one embodiment of the present invention. This graph illustrates the frequency response of the filter of Figure 7B. The frequency response curve shown in Figure 12 has the result of passing low-frequencies, passing high-frequencies along the diagonal line from lower right to upper left, and attenuating high-frequencies away from this diagonal line (e.g. along the horizontal and

vertical axis). Alternate filters to that of Figure 7B may be used when the alternate filter has a frequency response curve similar to that shown in Figure 12.

Referring now to Figure 13, a graph of a combined filter frequency response is shown, according to another embodiment of the present invention. In this alternate embodiment, instead of the two cascaded filters of Figure 7A and Figure 7B, a single convolution filter may be utilized. The single convolution filter of the Figure 13 embodiment may have a frequency response as given in Figure 13 or a frequency response similar to that given in Figure 13. The derivation of filter coefficients for use in a coefficient matrix, similar to coefficient matrices 700, 750, from a given frequency response graph is well-known in the art.

In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

CLAIMS

What is claimed is:

1   1.   A method for de-screening a halftone image, comprising:

2   performing a screen conversion filter upon a scanned

3   representation of said halftone image to produce an

4   intermediate image; and

5   performing a line smoothing filter upon said intermediate image

6   to produce an output image.

1   2.   The method of claim 1, wherein said screen conversion

2 filter utilizes a 3 by 3 coefficient matrix.

1   3.   The method of claim 2, wherein said coefficient matrix is

2 diagonal along the lower right to upper left direction.

1   4.   The method of claim 3, wherein coefficients $c_{(-1, 1)} = c_{(1, -1)} =$

2 1, and coefficient $c_{(0, 0)} = 2$.

1   5.   The method of claim 2, wherein said coefficient matrix is

2 diagonal along the lower left to upper right direction.

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1   6.   The method of claim 3, wherein coefficients $c_{(-1, -1)} = c_{(1, 1)} =$

2   1, and coefficient $c_{(0, 0)} = 2$.

1   7.   The method of claim 1, wherein said line smoothing filter

2   utilizes a 3 by 3 coefficient matrix.

1   8.   The method of claim 7, wherein said coefficient matrix is

2   diagonal along the lower right to upper left direction.

1   9.   The method of claim 8, wherein coefficients $c_{(-1, 1)} = c_{(1, -1)} =$

2   1, and coefficient $c_{(0, 0)} = 2$.

1   10.   The method of claim 9, wherein said coefficient matrix is

2   diagonal along the lower left to upper right direction.

1   11.   The method of claim 10, wherein coefficients $c_{(-1, -1)} = c_{(1, 1)} =$

2   1, and coefficient $c_{(0, 0)} = 2$.

1   12.   The method of claim 1, wherein said screen conversion

2   filter passes low-frequencies, passes high-frequencies along a diagonal

3   line from lower left to upper right, and attenuates high-frequencies

4   away from said diagonal line.

1   13.   The method of claim 1, wherein said screen conversion

2   filter passes low-frequencies, passes high-frequencies along a diagonal

3   line from lower right to upper left, and attenuates high-frequencies

4   away from said diagonal line.

1   14.   The method of claim 1, wherein said line smoothing filter

2   passes low-frequencies, passes high-frequencies along a diagonal line

3   from lower left to upper right, and attenuates high-frequencies away

4   from said diagonal line.

1   15.   The method of claim 1, wherein said line smoothing filter

2   passes low-frequencies, passes high-frequencies along a diagonal line

3   from lower right to upper left, and attenuates high-frequencies away

4   from said diagonal line.

1   16.   A method for de-screening a halftone image, comprising:

2   performing a single convolution filter upon a scanned

3   representation of said halftone image to produce an

4   output image, wherein said single convolution filter equals

5   the resulting convolution of a screen conversion filter and a

6   line smoothing filter.

1   17.   The method of claim 16, wherein said single convolution

2   filter passes low-frequencies, passes high-frequencies at a central area,

3   and attenuates high-frequencies along a horizontal axis and a vertical

4   axis.

1   18.   A computer-readable medium having stored thereon

2   sequences of instructions, the sequences of instructions including

3   instructions which, when executed by a processor, causes the processor

4   to perform various processing, the sequences of instructions

5   comprising:

6   a first sequence to perform a screen conversion filter upon a

7   scanned representation of a halftone image to produce an intermediate

8   image; and

9   a second sequence to perform a line smoothing filter upon said

10   intermediate image to produce an output image.

1   19.   A computer-readable medium having stored thereon

2   sequences of instructions, the sequences of instructions including

3   instructions which, when executed by a processor, causes the processor

4   to perform various processing, the sequences of instructions

5   comprising:

6   a first sequence to perform a single convolution filter upon a

7   scanned representation of a halftone image to produce an output image,

8   wherein said single convolution filter equals the resulting convolution of

9   a screen conversion filter and a line smoothing filter.

1   20.   A system for de-screening a halftone image, comprising:

2   a memory to store an input image from a halftone print; and

3   a processor to perform a screen conversion filter upon said input

4   image and create an intermediate image, and to perform a

5   line smoothing filter upon said intermediate image and

6   create an output image.

1   21.   A method for de-screening a halftone image, comprising:

2   converting dots of said halftone image into parallel lines of an

3   intermediate image; and

4   smoothing said parallel lines of said intermediate image into a

5   final image.

1   22.   The method of claim 21, wherein said parallel lines are at

2   an approximately 45 degree angle with respect to a side of said

3   intermediate image.

ABSTRACT OF THE DISCLOSURE

A method and apparatus for de-screening a halftone image, therefore allowing the recovery of an approximation of an original image, is disclosed. A method according to one embodiment first

5   performs a screen conversion filter upon a scanned representation of the halftone image to produce an intermediate image. This method then performs a line smoothing filter upon the intermediate image to produce an approximation to the original image.

In an alternate embodiment, the method performs a single

10   convolution filter upon a scanned representation of the halftone image to produce an approximation to the original image. In this embodiment, the single convolution filter is equal to the resulting convolution of first performing a screen conversion filter and then performing a line smoothing filter.

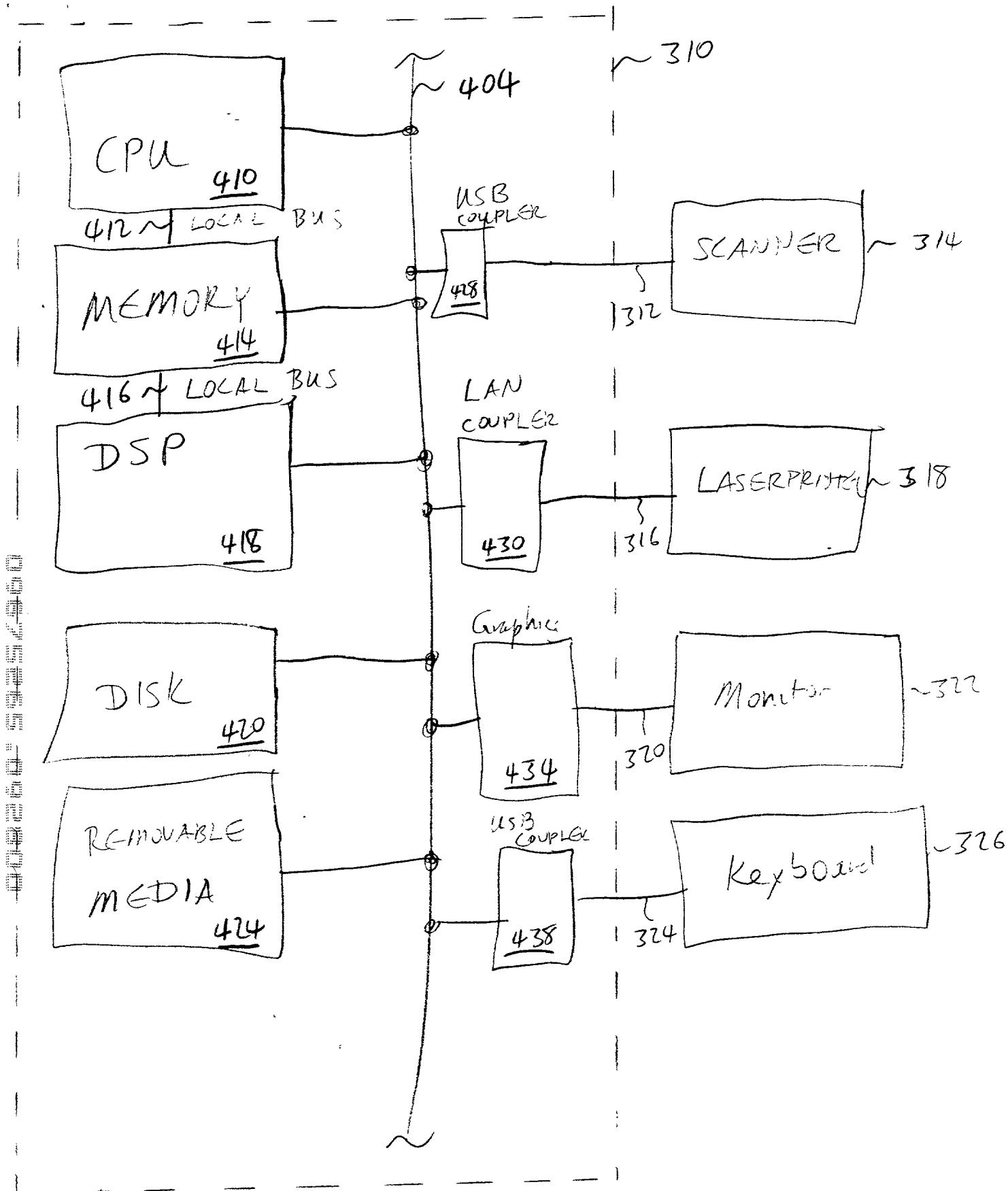003551.P007   -24-
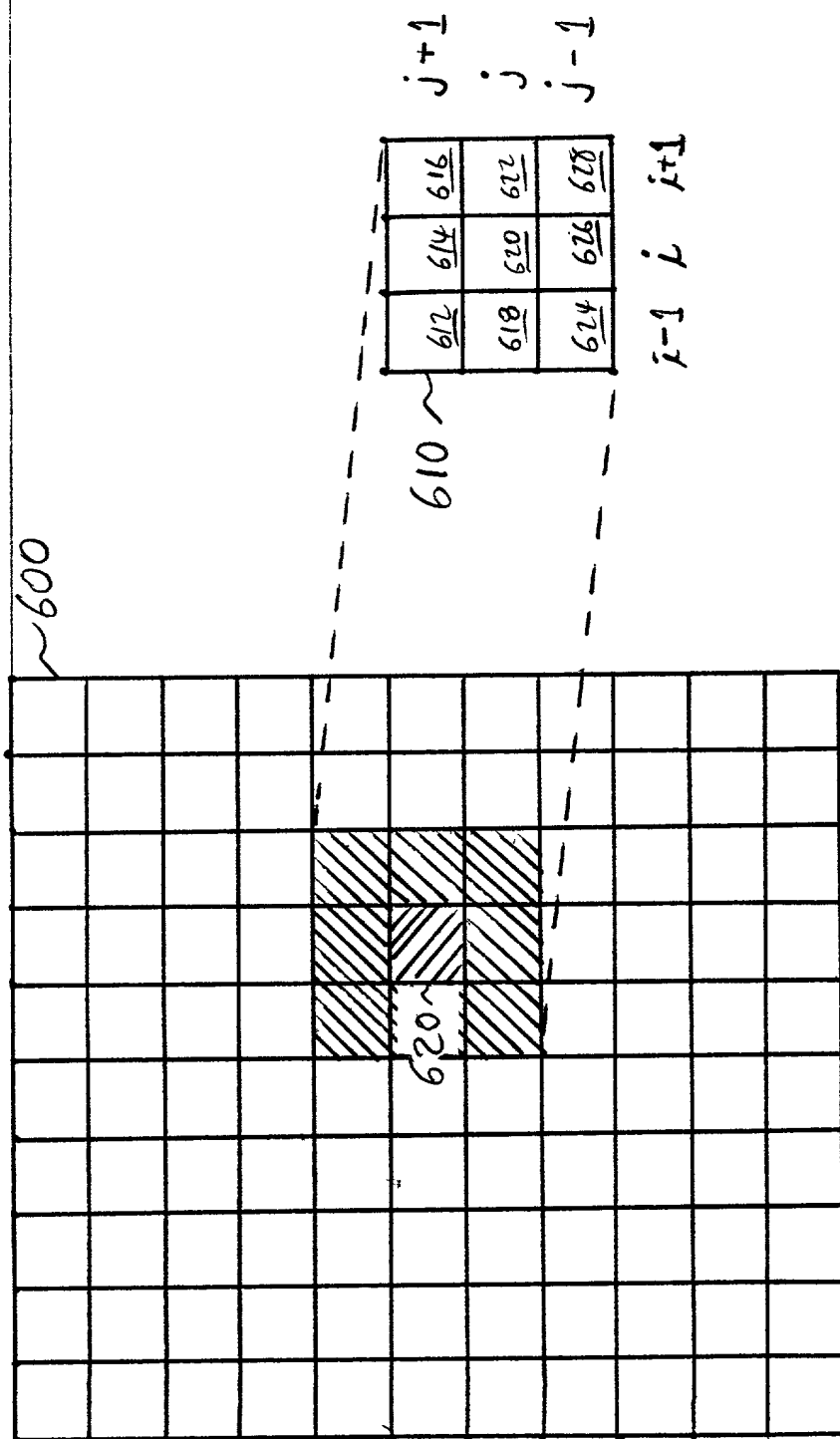
FIGURE 1

Traditional Screen Angles

FIGURE 2

SCANNER 314

350

360

LASERPRINTER 318

312

316

COMPUTER 310

324

322

MONITOR 322

KEYBOARD

326

300

FIGURE 3

CPU **410**

412 ~ LOCAL BUS

MEMORY **414**

416 ~ LOCAL BUS

DSP **418**

DISK **420**

REMOVABLE MEDIA **424**

~ 404

~ 310

USB COUPLER **428**

SCANNER ~ 314

312

LAN COUPLER **430**

LASERPRINTER ~ 318

316

Graphics **434**

Monitor ~ 322

320

USB COUPLER **438**

Keyboard ~ 326

324

FIGURE 4

Scanning Driver — 510

First Convolution Filter — 520

Second Convolution Filter — 530

414

FIGURE 5

FIGURE 6

700

1	0	0
0	2	0
0	0	1

$c_{k\ell}$

$c_{-1,1} = c_{1,-1} = 1$

$c_{0,0} = 2$

All other $c_{k\ell} = 0$

$$b_{ij} = \sum_{k=-1}^{1} \sum_{\ell=-1}^{1} a_{(i+k)(j+\ell)} \, c_{k\ell}$$

$$= a_{(i-1)(j+1)} + a_{(i+1)(j-1)} + 2\, a_{ij}$$

FIGURE 7A

750

0	0	1
0	2	0
1	0	0

$c_{k\ell}$

$c_{-1,-1} = c_{1,1} = 1$

$c_{0,0} = 2$

All other $c_{k\ell} = 0$

$$b_{ij} = \sum_{k=-1}^{1} \sum_{\ell=-1}^{1} a_{(i+k)(j+\ell)} \, c_{k\ell}$$

$$= a_{(i+1)(j+1)} + a_{(i-1)(j-1)} + 2\, a_{ij}$$

FIGURE 7B

IMAGE SCANNED USING THE ASTRA 2400S
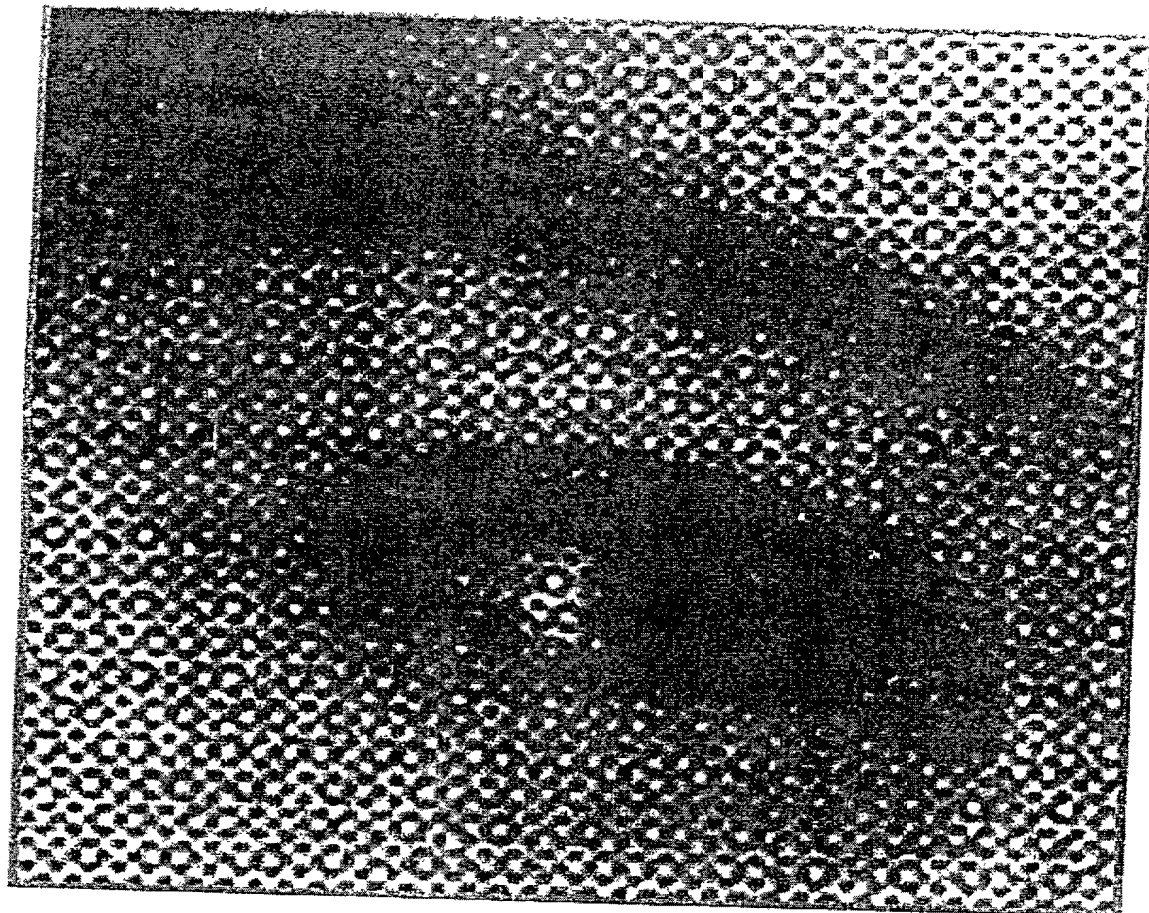
FIGURE 8

OUTPUT OF FIRST CONVOLUTION FILTER
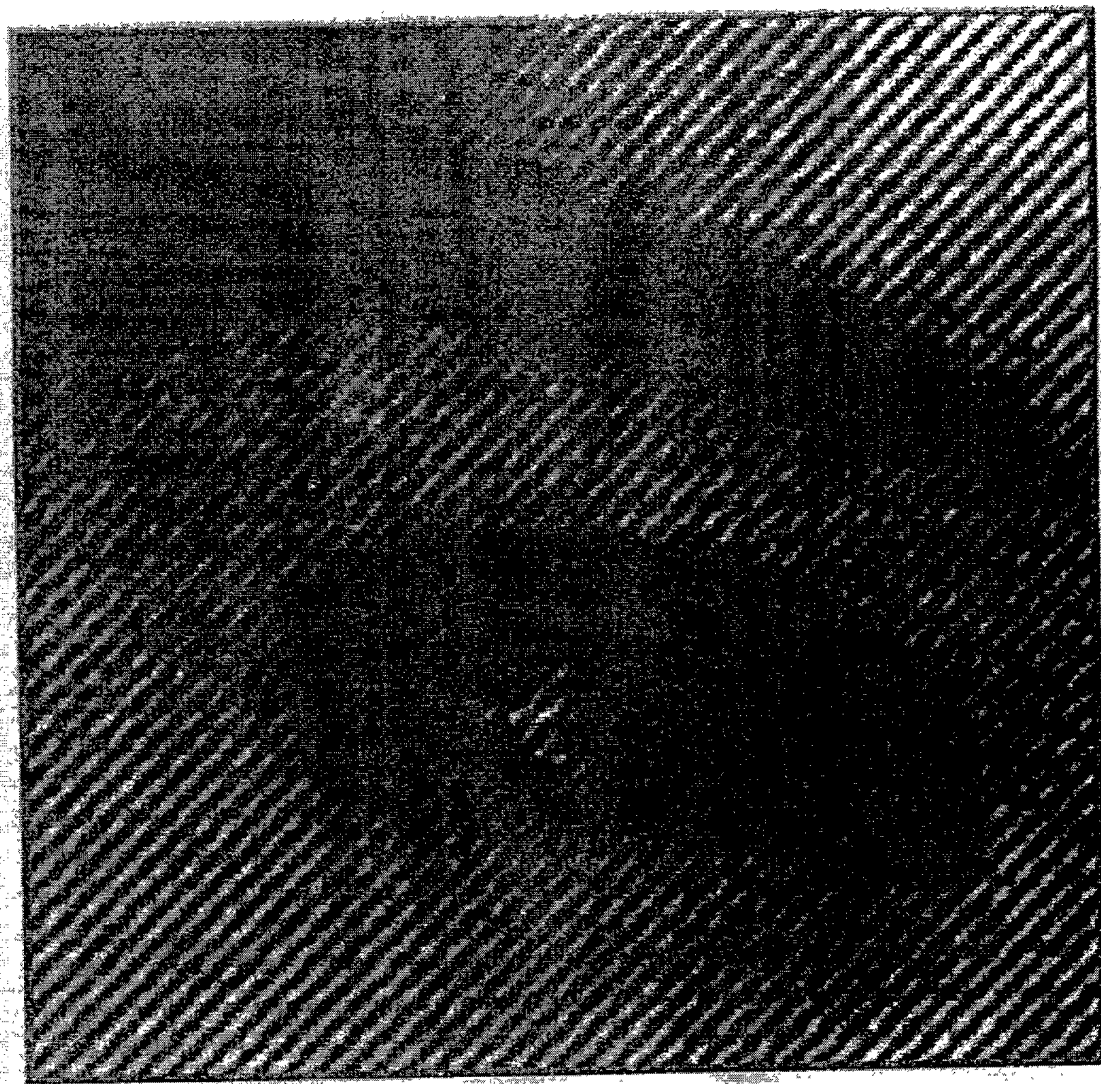
Figure 9

OUTPUT OF SECOND CONVOLUTION FILTER

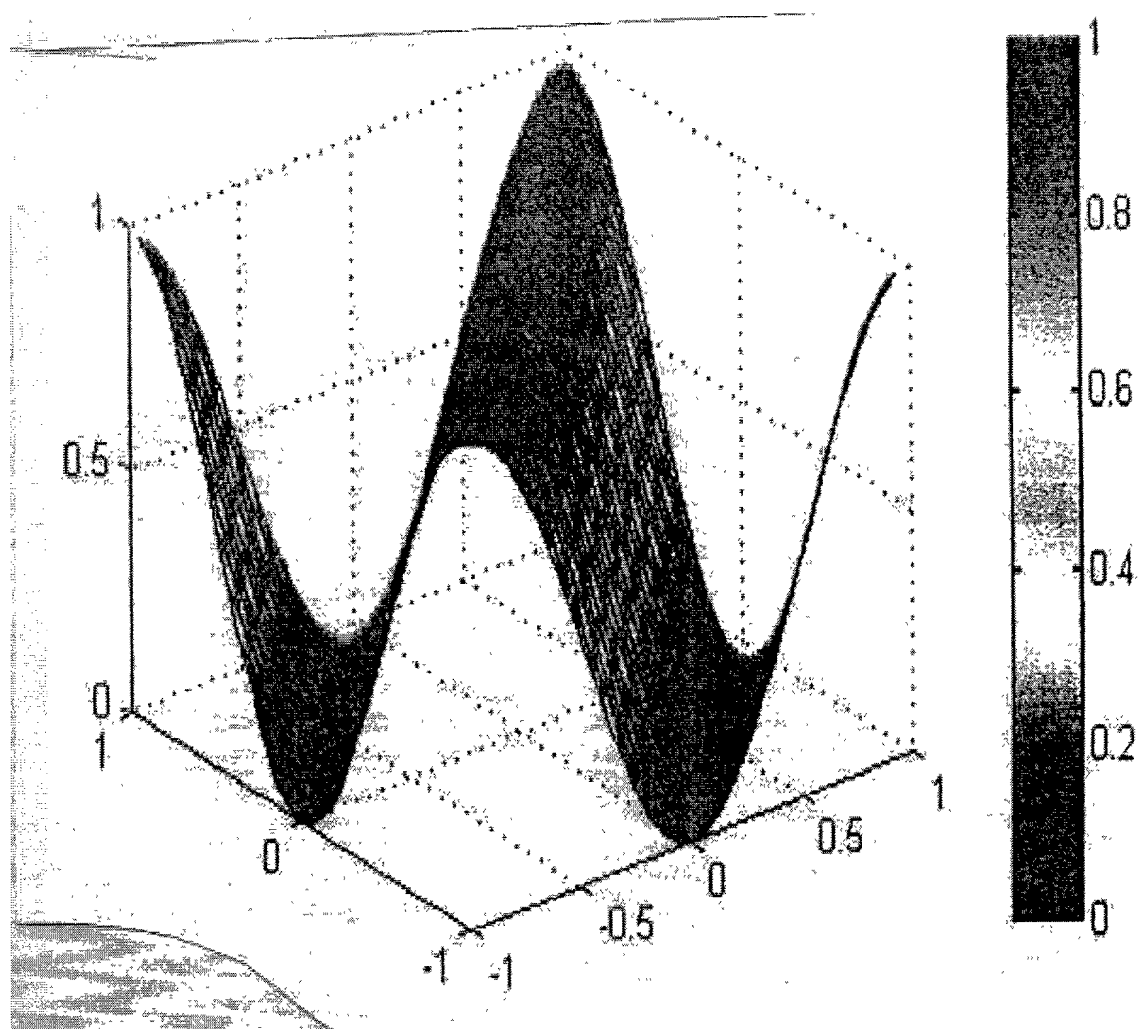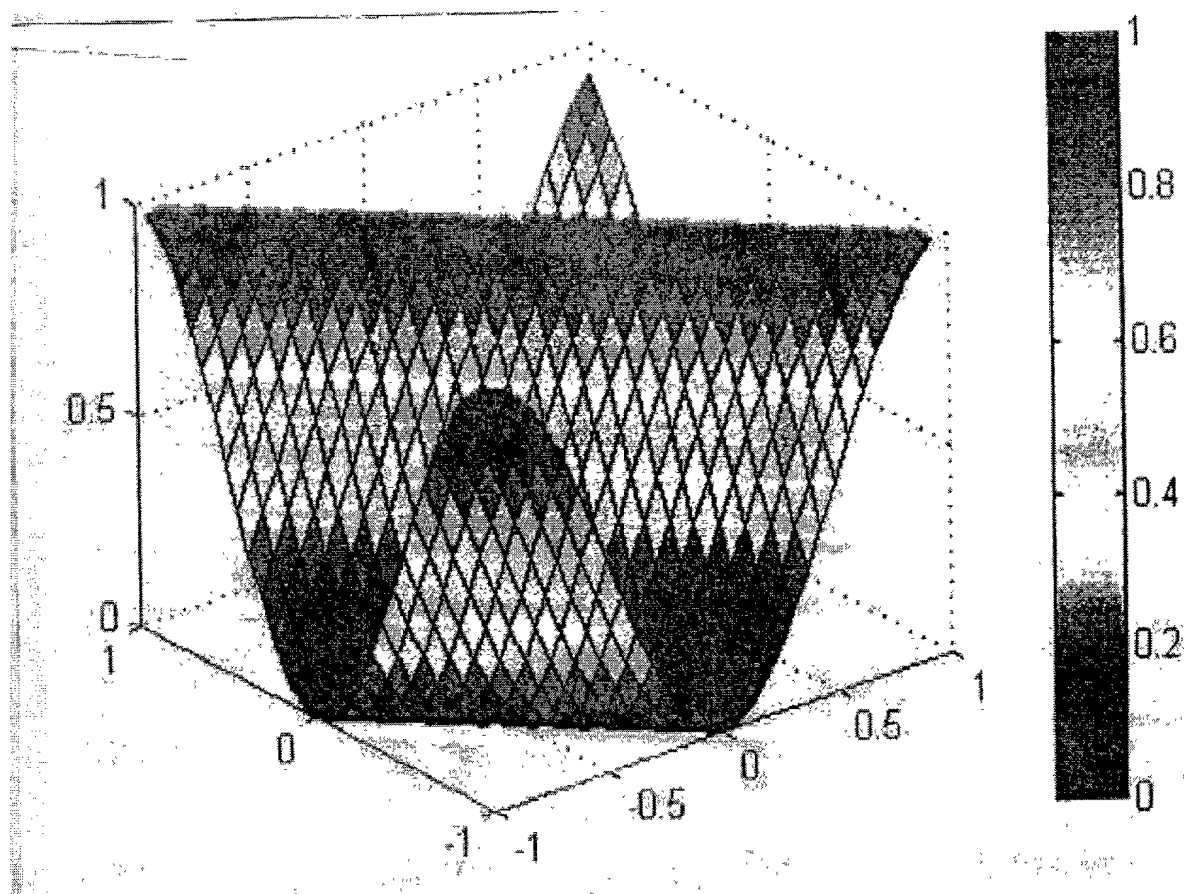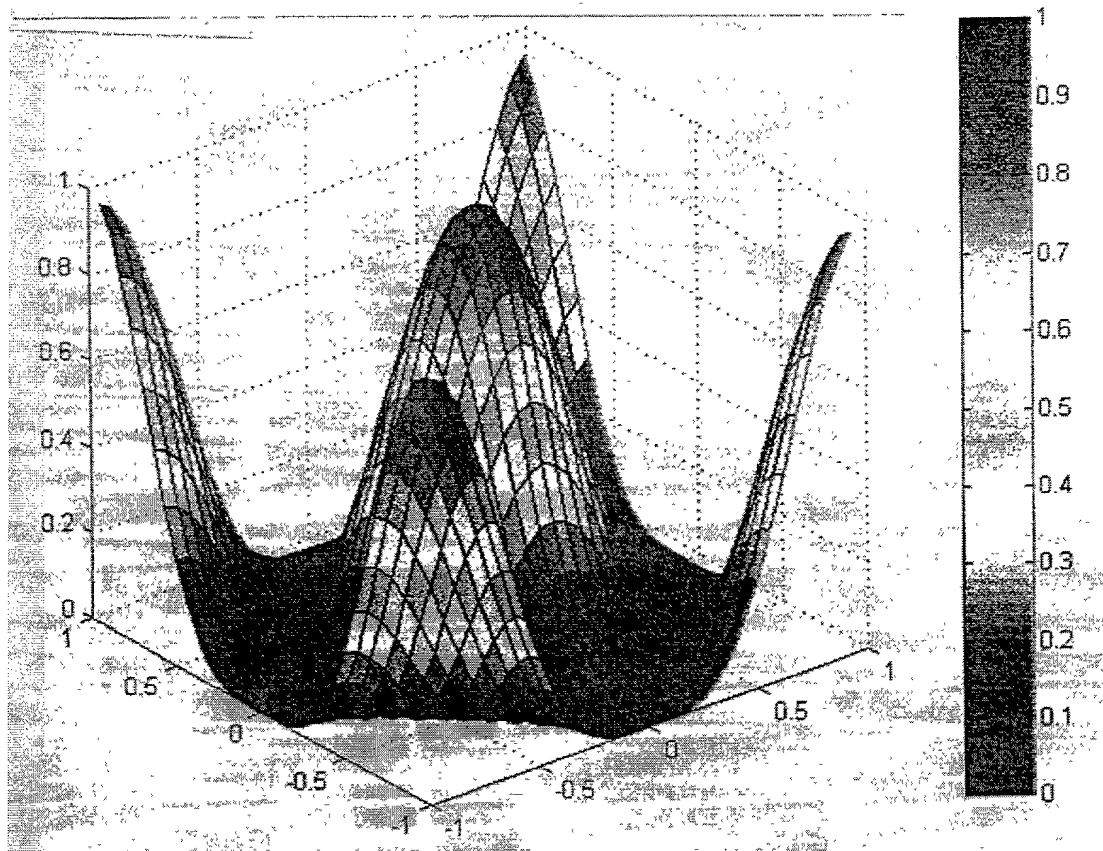**FIGURE 10**

SCREEN CONVERSION FILTER FREQUENCY RESPONSE

FIGURE 11

LINE SMOOTHING FILTER FREQUENCY RESPONSE

FIGURE 12

DESCRIPTION FILTER FREQUENCY RESPONSE

FIGURE 13

<u>DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION</u>

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

SYSTEM AND METHOD FOR A ROBUST DE-SCREENING FILTER

the specification of which

   <u>X</u>   is attached hereto.
   <u>   </u>   was filed on _____ as
            United States Application Number _____
            or PCT International Application Number _____
            and was amended on _____.
                                      (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below:

_____   _____
(Application Number)   Filing Date

_____   _____
(Application Number)   Filing Date

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

_____ _____ _____
(Application Number)   Filing Date   (Status -- patented,
                                                      pending, abandoned)

_____ _____ _____
(Application Number)   Filing Date   (Status -- patented,
                                                      pending, abandoned)

I hereby appoint the persons listed on Appendix A hereto (which is incorporated by reference and a part of this document) as my respective patent attorneys and patent agents, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

Send correspondence to <u>Dennis A. Nicholls</u>_____, **BLAKELY, SOKOLOFF, TAYLOR &**
                                    (Name of Attorney or Agent)
ZAFMAN LLP, 12400 Wilshire Boulevard 7th Floor, Los Angeles, California 90025 and direct
telephone calls to <u>Dennis A. Nicholls</u>_____, **(408) 720-8300.**
                          (Name of Attorney or Agent)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Sole/First Inventor <u>Thomas W. Jewitt</u>_____

Inventor's Signature ___*Thomas W. Jewitt*_____ Date __<u>8/3/2000</u>_____

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APPENDIX A

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APPENDIX B

Title 37, Code of Federal Regulations, Section 1.56
Duty to Disclose Information Material to Patentability

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclosure information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclosure all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

    (1)   Prior art cited in search reports of a foreign patent office in a counterpart application, and

    (2)   The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

    (b)   Under this section, information is material to patentability when it is not cumulative to information already of record or being made or record in the application, and

    (1)   It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

    (2)   It refutes, or is inconsistent with, a position the applicant takes in:

    (i)   Opposing an argument of unpatentability relied on by the Office, or

    (ii)   Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

    (c)   Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

    (1)   Each inventor named in the application;

    (2)   Each attorney or agent who prepares or prosecutes the application; and

    (3)   Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

    (d)   Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.